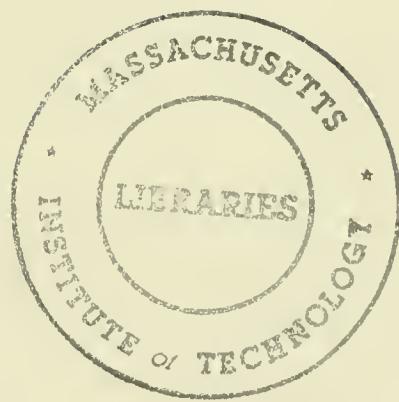


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STRUCTURAL EFFECTS OF COMMUNICATION TECHNOLOGIES
ON FIRMS: LESSONS FROM THE PAST

by JoAnne Yates

WP 1655-85

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MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139



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LESSONS FROM THE PAST

Past and Present

In the midst of today's revolution in information and communication technology, we often lose sight of the past. We see computers and computer-based communications as wholly new developments that have no precedents. Yet the technology of communication and information has been evolving for thousands of years. By studying how past changes in communication technology have affected the organizations using these technologies, we can gain insight into the effects of current technological changes on organizations. Such insights should be particularly valuable to a large scale research project on this topic, such as the Management in the 1990s project undertaken in MIT's Sloan School of Management.

The past is not, of course, a perfect model for the future. Changes in technology, whether in the past or the present, occur not in isolation, but simultaneously with other types of changes. Thus we should not expect the past to predict the future. Nevertheless, a study of the effects of past developments in communication technology can certainly illuminate some developments we are seeing today and suggest types of structural effects that may occur under certain conditions. These patterns of structural change can at least provide a useful framework for exploring the effects of current developments. Given the stakes involved in understanding the effects of current technological

changes, we cannot afford to neglect such an important source of data.

The second half of the nineteenth century is a particularly rich period for studying the effects of technological change. During that time a series of developments beginning with the telegraph and ending with duplicating and filing created a communication and information revolution comparable in impact to the revolution occurring today. (See Fig. #1.) The new technologies and processes changed utterly the way information was handled and communicated within and between firms. Because of the other changes occurring during the same period, such as changes in manufacturing processes and managerial ideology, the effects of changes in communication technology are not easily isolated. Moreover, these effects have not received very much study.¹ The historical record such as it is, however, provides a basis for linking the changes in communication technologies more or less strongly to a number of structural changes in firms.

The changes in firms that seem to be linked to changes in communication technology occurred on at least three structural levels:

- the overall structure of firms
- the structure of information/communication flows
- J -the structure of managerial and clerical jobs

This document outlines the effects, to the extent that they are now known or can be hypothesized, of one or more changes in communication technology on each of the three structural levels.

I will use the introduction of the telegraph to illustrate effects on the size and structure of the firm as a whole; changes in duplicating and filing technology, first, and the advent of the telephone, second, to illustrate two different types of effects on the structure of communication and information flow within the firm; and the introductions of all of these technologies to illustrate effects on the structure of clerical and managerial jobs within the firm. In each case, I will begin with a problem of modern technological change, trace an historical case of change that may illuminate that modern problem, then briefly return to the modern problem to suggest parallels. Thus this paper should suggest possible avenues for research on and interpretation of the effects of recently introduced modern technologies. Furthermore, since current historical knowledge in these areas is far from extensive, I hope to receive comments on which of the structural levels or specific historical technologies warrant further study to illuminate current issues.

THE STRUCTURE OF THE FIRM

While many immediate effects of communication technologies on firms are evident all around us, longer term effects on the overall structure of firms may not be so easily observed. Yet the relationship between new technology and firm structure, as the Management in the 1990s paradigm suggests, is a critical one. How will improvements in computer communications affect firm structure? The case of the telegraph and its effects on firm

structure may illuminate that issue.

The Telegraph and Vertical Integration

The invention of the telegraph, in 1844, affected the nineteenth century business world dramatically. Before the telegraph, information travelled only as fast as people did; afterwards, it could travel virtually instantaneously. The telegraph's probably affect on the structure of manufacturing firms was particularly interesting. Until the late nineteenth century most manufacturing firms focused exclusively on production, leaving distribution to be handled through independent agents and wholesalers. In the 1880s, however, a wave of forward integration into distribution began. As Fig. 2 indicates, evidence suggests that the telegraph encouraged this vertical integration, both indirectly and directly.

The argument for an **indirect** influence, derived from Alfred Chandler's work,² has three intermediate steps. The railroad and the telegraph together, he argues, expanded the market a given firm could reach and adequately serve by radically speeding up both communication and transportation. Cities once considered too distant to serve suddenly became accessible. This widening of potential markets encouraged firms to increase production, frequently by adopting new machinery and methods of mass production. While the railroad and telegraph facilitated the rapid movement of raw materials into and finished products out of the factory, the older distribution methods were often inadequate

to the new level of production. This inadequacy drove many companies to internalize the distribution function, setting up sales offices in various locations. Administrative coordination, Chandler argues, often proved more efficient than market coordination, lowering transaction and information costs and using production facilities more efficiently. (Presumably markets were imperfect, allowing administrative coordination to offer advantages.)

We can envision this indirect effect in a simpler form, as well. Before forward integration, companies generally hired independent agents in various cities to market the company's products to wholesalers and retailers. Each agent usually served a number of companies. Only when a company had enough business to require a full-time representative was forward integration feasible. When the railroad and telegraph increased the amount of business with distant cities, many companies finally reached that threshold. At that point, the desire for closer control might prompt the company to take on (or convert the agent into) its own sales representative. Thus this version of the indirect affect also depends on the widening of a firm's markets.

The **direct** pressures towards vertical integration, on the other hand, depend on the telegraph's characteristics as a mode of communication. First, by reducing the cost of internal transactions more than the cost of external transactions, the telegraph could promote internalization of the distribution function previously handled by market transactions. Second, by

allowing instantaneous communication, the telegraph made possible a degree of administrative coordination not possible before, but extremely efficient.

The telegraph directly promoted vertical integration by making internal transactions less expensive and more secure than external, market-mediated ones. A principal mechanism through which the telegraph favored internal transactions was telegraphic codes. Early in the history of the telegraph, codes were developed to reduce the number of chargeable words and to maintain confidentiality over public wires.³ Widely available general business codes were used between companies or between a company and an agent serving many companies. Companies with their own agents or sales offices in various cities, however, often developed their own private codes. These private codes, tailored to the nature of their businesses, reduced costs even more than the general purpose codes, cutting the number of words by as much as half, as well as maintaining better privacy.⁴ Moreover, non-contractual internal transactions could be routinized and simplified to take maximum advantage of the cost saving codes. Finally, any legal work associated with external transactions still had to be sent through the mails, thus slowing down external transactions over internal ones. All of these factors lowered internal transaction costs more than external ones and encouraged forward integration.

In addition to favoring internal over external transactions, the telegraph made possible a degree of administrative

coordination over distances never before possible. In some cases this coordination made vertical integration efficient and desirable. The meat packing industry exemplifies this effect.⁵ Because meat was perishable, transportation and coordination provided particular problems for that industry. Until the 1880s, cattle, not dressed meat, travelled east from midwestern cattle country, to be sold to middlemen and slaughtered near its ultimate markets. With the development of refrigerated railroad cars in 1881, meat packers could slaughter cattle in massive slaughter houses in the mid west then ship the dressed meat east, keeping it chilled in the special cars. Even chilled, however, beef was perishable; thus its location and movement had to be carefully and efficiently controlled all the way to the retail outlets to prevent spoilage. The close coordination was achieved through internal, telegraphic communication in large, vertically integrated companies.

The initial forward integration into distribution was prompted more by the railroads than by the telegraph, but the telegraph helped make the newly vertically integrated companies successful. Initially, the railroads refused to provide refrigerator cars because shipping cattle was more lucrative for them than shipping beef. A few meat packers such as Armour and Swift responded by building their own refrigerator cars and establishing networks of branch distributing houses. Daily telegraphic contact between managers at every facility allowed them to control the flow of cattle and then dressed meat through

production and distribution with minimal delays and losses. With this tight coordination, these companies could take full advantage of improved production facilities and refrigerator cars. By internalizing the distribution function and coordinating it telegraphically, meat packers developed enormous and profitable businesses.

Of course, the economics of the internalization could have changed at a later point if companies specializing in parts of the distribution function could have been efficiently coordinated by the market through external use of the telegraph. The oligopolistic nature of the industry by the turn of the century, however, along with the other direct effects discussed above, kept the balance in favor of internalization. In this case and others, then, the telegraph encouraged vertical integration by making possible and profitable closely integrated production and distribution.

The telegraph, then, seems to have promoted forward integration of American manufacturing companies both indirectly, by helping expand markets, and directly, by favoring internal over external transactions and by making possible certain types of highly efficient administrative coordination that were not previously possible. But how can this historical example illuminate the present? Let us look briefly at a contemporary case with possible parallels.

Contemporary Application: Data Flows

Recent technological advances have allowed more rapid and less expensive transfers of large amounts of data from computer to computer, especially in the international arena. If these improvements are analogous to the improvements brought by the telegraph, they may encourage, both directly and indirectly, forward integration into marketing of products internationally. The **indirect** effect would operate by widening markets for businesses in information-rich industries, especially into foreign countries not previously easily accessible, and encouraging expanded production or services for them. Then, if international brokers were not handling stepped-up international marketing adequately, companies might internalize that function. Of course, that forward integration would only last if it could be handled more efficiently internally than externally.

Both types of **direct** effect might also operate. The ability to transfer large amounts of data quickly and inexpensively might make possible a degree of administrative coordination never before possible. The improved coordination made possible through such data communication could, of course, come to be handled by the market or by an external broker. The other direct effect, the favoring of internal over external transactions, might prevent that shift in some cases through a mechanism roughly analogous to telegraph codes: compatibility of computer hardware and software. Compatibility of systems and of processing routines makes data transfers quicker and less

expensive, as well as more private. This effect might help entrench the new types of administrative control, at least unless or until some standards are established to overcome compatibility problems.

The historical analogy is not likely to be complete, however. Political, legal, and linguistic boundaries between nations enter into the international situation, creating various differences in the overall effect of the technology. In fact, a new international organization, The International Institute for Informatics, has been created to reduce some of the legal and technical problems of "transborder data flows." In spite of such differences, the historical analogy provides a starting point in thinking about effects of this technology. Moreover, the case of the telegraph may yield insights into the effects of other modern communication technologies on the structure of firms.

THE STRUCTURE OF COMMUNICATION/INFORMATION FLOWS

Moving down from the level of the firm as a whole to the level of communication and information flows within the firm, we can once again see major issues and questions raised by modern advances in technology. For example, as mainframe computers have been joined by microcomputers, the implications of centralization or decentralization of information control have been much debated. For another example, as new communication media proliferate, companies and individuals face decisions about which systems to buy and how to use them. Thus they need to understand the roles

played by different communication media and the possible impact of new media on existing modes of communication. These issues are not new, though the details of the debate are. Again we can turn to the past to illuminate these current issues.

Duplicating and Filing Technology and Decentralization of Files

While developments in duplicating and filing were much less dramatic than the invention of the telegraph, they had a profound impact on communication flow within the firm.⁶ Before these developments, a firm's files were, of necessity, centralized. As Fig. 3 illustrates, these changes made possible decentralized storage and retrieval of information. The internal communication promoted (and in turn was promoted by) the proliferation of files.

In the mid-nineteenth century, the technology for duplicating documents dictated that company correspondence files be centralized. The only available method for duplicating outgoing correspondence other than hand copying was the letter press. This device used pressure to make a single dim copy of each letter onto the dampened tissue paper pages of bound volumes called press books. Thus copies of all outgoing letters were bound in chronological order in centrally maintained volumes, sometimes indexed in the front by the name of the correspondent. Incoming letters were kept in pigeonholes or in letter boxes in the same central office. At this stage virtually no written internal communication existed.

As firms grew in the late nineteenth century, increased

external correspondence and the development of internal written communication made this system of duplicating and filing increasingly unwieldy to use. Locating both sides of an external correspondence, for example, involved going to two different systems (press books and letter boxes) organized in different ways (the former chronologically and the latter generally by correspondent). Moreover, when internal correspondence grew up, it did not fit into the existing system. Many downward communications needed to go to a wide audience, but the only method of reproducing a document in multiple copies was the expensive printing process. Storage was also a problem. For one party the communication might be outgoing, but for the other(s) it was incoming. Moreover, the central files were inconvenient and inaccessible, at least in perception if not always in fact, for many internal units far from the central office. And since press books were indexed and letter boxes organized by correspondent rather than by subject, an internal notice on a given subject would be hard to locate later in either system.

These pressures made larger companies quick to adopt a series of developments in duplicating and filing technology in the late decades of the century. Once the typewriter was widely adopted, carbon paper (which existed much earlier but could not be used with quill or steel tipped pens) became an easy way to make up to a half dozen unbound copies that could be stored anywhere. The mimeograph and other methods of stencil duplicating, developed during the last two decades of the century, made it possible to

create large numbers of copies, especially useful in the newly developing downward communication. Finally, vertical filing, introduced to the business world at the Chicago World's Fair of 1893, provided a method for storing unbound papers. It allowed related incoming, outgoing, and internal communication all to be filed together and organized by any method desired, including by subject. Files became a flexible and accessible organizational memory.

While these new technologies allowed, for the first time, multiple sets of files in the same company, the desire for local control of internal communication promoted proliferation of files. Although the new duplicating technologies allowed multiple, unbound copies, books on vertical filing discouraged any decentralization, arguing that a centralized filing and retrieval system was more efficient. Nevertheless, sets of files in companies multiplied around the turn of the century. While correspondence with customers frequently was kept in central files, internal correspondence (as well as some correspondence with suppliers) was increasingly stored in local files (in departments and smaller units) where its senders and recipients could control it and refer to it at any time.

While the growth of internal written communication encouraged proliferation of files at department and unit levels, this proliferation in turn encouraged additional internal correspondence. An early twentieth century study at the Pennsylvania Railroad showed that by eliminating files below the

division level, the company could reduce internal correspondence by 20%.⁷ Apparently, much of the correspondence between units was intended less to communicate information efficiently than to document relations between units. The Pennsylvania Railroad saw the elimination of local files and the resulting documentary correspondence as an improvement in efficiency. Yet the local files were not necessarily ineffective; by providing flexible and accessible departmental memories that could be consulted at any time, these files served an important function in allowing departments to learn from past actions. Because the files were locally maintained, managers consulting them might notice other relevant materials when retrieving some specific document. Thus the total effect on productivity is virtually impossible to judge in retrospect.

Contemporary Application: PCs and the Decentralization of Data

Once again, the historical case may illuminate a contemporary one, the decentralized storage and manipulation of data allowed by the spread of personal computers. Using the above example to help us interpret the structural effects of PCs, we might suggest that the new microcomputer technology allows the decentralization of much data storage and manipulation, but that desire for local control of data both promotes and is promoted by that decentralization.

Clearly microcomputer technology permits a shift in many data storage and computing tasks from a centralized data processing

department to local units. Managers who once dealt with the data processing department to fulfill all their data needs now can purchase inexpensive PCs and do much of their computing themselves. Their desire to reduce their dependence on the central data processing department and to increase their local control is surely a factor pushing the current proliferation of PCs. This mode of computing may be less efficient (in terms of labor and equipment) for any given task, but it gives managers much more control over data and its uses. As managers gain hands-on experience in using the PCs, they may discover new and productive uses of data. Thus the technology's total effect on productivity, like the total effect of decentralized filing, is more difficult to ascertain.

The two cases clearly differ in many ways, as well. PCs, for example, can communicate with mainframes so that some advantages of both centralization and decentralization can be realized. Nevertheless, the historical case gives us a useful way of looking at the impact of PCs on the flow of information in the firm.

Effect of the Telephone on Communication Channels in the Firm

The previous example concerns the effects of centralization and decentralization on flows of information in a firm. This example focuses on the effect of a new technology on a different aspect of information flow: the use of various communication media in the firm. The telephone, introduced in 1876 and commonly available within firms by the 1890s, supplemented (and probably displaced some) face-to-face communication to extend oral communication throughout the sprawling factory complexes growing up during that time. In contrast, it complemented written communication; indeed, the role of written internal communication developed and expanded rapidly during these years. (See Fig. 4)

At the time of the telephone's invention, almost all communication within a given site was face-to-face oral communication. Correspondence and a set of bound ledgers kept a written record of transactions with the outside world, but internal management was primarily handled orally. For the most part, orders were given, processes were coordinated, and information was gathered orally. Occasionally, a set of rules might be printed up and posted throughout a facility. And in larger facilities or in companies with a plant separated from an office, written notes carried by messengers were used to bridge distances when the parties did not have time for a face-to-face encounter, a practice that might have been expected to grow as companies grew.

When the telephone appeared on the scene, then, it seemed

likely to displace that small amount of written internal communication that was growing up to span distances as plants expanded. For example, one of the first point-to-point telephone connections established in 1876 was between the Cambridge Bureau of Waterworks and its Fresh Pond works, eliminating the need for messengers to travel back and forth between the two locations with notes.⁸ In fact, however, the period between the introduction of the telephone and the spread of private branch exchanges within firms in the 1890s saw the beginnings of a series of changes in organizational structure, managerial philosophy, and communication patterns -- changes that continued into the twentieth century. In the context of these changes, the telephone took on a role in internal communication very different than might have been expected in 1876.

The changes in organizational structure and managerial philosophy that began during this period required a change in the role of written communication in firms. The 1880s and 1890s, as Alfred Chandler has described in The Visible Hand, saw enormous growth of firms, both horizontally and vertically. Growth was accompanied by specialization and departmentalization of various functions. These changes posed challenges for old, haphazard methods of management. A new managerial philosophy, systematic management, grew up as an attempt to answer these challenges.⁹ This philosophy rejected ad hoc oral management at the foremen's level in favor of systematic methods established and evaluated from higher managerial levels. These systematic methods

were heavily dependent on written communication. Written notices and rules established the methods, and systems of routine written reports pulled data up the hierarchy where it could be analyzed and performances could be evaluated. Yet more written communications documented lateral transactions and relationships across and within departments for future reference. The result was an explosion of internal written communication within companies.

Meanwhile, the telephone system itself had to evolve before extensive internal telephone use was possible. Although the telephone had been used among different businesses and individuals since 1876, originally across individually strung, point-to-point wires and later through public exchanges, the private branch exchanges that allowed extensive connections within a given facility did not really become common until the 1890s.¹⁰ Up to that point most expansion of the telephone system took place in public exchanges. At that point a change in rate structure and private competition gave the Bell system incentive to install increasing numbers of PBXs. In the 1890s and the early years of the twentieth century, PBXs sprang up in most large facilities, enabling individuals at opposite ends of sprawling plants or offices to communicate orally. Available statistics show enormous internal use in many companies, often surpassing use of external trunk lines into the public exchanges.¹¹ What role, then, did the telephone play in internal communication in firms?

The existence and nature of extensive written records from

the period strongly suggest that the telephone generally complemented, rather than displaced or directly supplemented, written internal communication.¹² In fact, by replacing most of the small amount of written communication that had the sole purpose of bridging distance within a facility when time did not permit face-to-face encounters, the telephone clarified the role of written communication, in contrast to oral communication. Written communication could be used solely when uniformity (in downward communication), specificity (especially in upward communication), or documentation (in any type of communication) was desireable. In such cases, the telephone, though often quicker, was simply not capable of performing the desired function. Thus it did not replace such communication. Moreover, the telephone probably even encouraged the growth of written communication. Increasingly during this period, internal communications begin with such phrases as "Confirming our telephone conversation of . . ." By allowing increased oral communication, the telephone almost surely created more interactions, some of which needed to be documented.

While the written record suggests what the telephone was not used for, we can only speculate about what it was used for, since it leaves no permanent record. Judging from its capabilities and current use, we can assume that the telephone supplemented face-to-face communication in cases where immediacy, two-way discussion, and verbal and vocal feedback were desireable. Written communication simply could not provide those qualities.

In some cases, the telephone probably displaced face-to-face communication. (Thus the total amount of face-to-face communication for any given employee may not have decreased, though its percentage of total communication probably did.) The two are not perfect substitutes, however, since the telephone lacks visual cues. Although no evidence on this point remains, we may assume that then, as now, the most sensitive issues were still handled face to face. In sum, the telephone probably made more total internal communication possible for any given manager.

Thus the introduction of a new communication medium affected the use of existing media within the firm, but in a way that made use of the key strengths of each and totally displaced none. The telephone's failure to displace written communication suggests that the two media were (and are) used for different purposes. Communication serves a variety of purposes for which different media are not necessarily interchangeable.

Application: Electronic Mail and Voice Mail Systems

This historical example suggests that in assessing the probable role and impact of such new communication technologies as electronic mail and voice mail systems, the qualities each medium offers and the purposes of various types of communications be taken into account. As more communication media become available, the necessary distinctions between purposes of communications and capabilities of media become finer, but they are critical in assessing the likely role of a new medium.

To begin such an analysis for electronic mail and voice mail, we might think of them in comparison to existing media. Both new media allow a communication to be transmitted immediately, but received at the recipient's leisure, thus eliminating transmission time for written documents and telephone tag time for telephone messages. In comparison to telephone, however, neither mode offers real time, two-way discussion with immediate feedback verbally and vocally. Voice mail is more personal and better at conveying feelings than electronic mail, because it includes voice tones, but it does not generally allow revision to improve organization or tone. Moreover, long voice messages are not easily skimmed or "reread" selectively. Like paper-based written communication, electronic mail can convey very precise information and can be revised, but terminals are inconvenient for reading longer documents. Also, while electronic mail generally offers adequate short term storage, and thus will serve short-term documentation needs, not much is known about the life span of disks and computer tapes, so important internal documents will probably continue to be saved on paper, at least for now.

All such issues need to be considered to determine exactly what role new media will play in internal communication, if they are adopted. Such analysis can also help firms decide whether a new medium offers enough advantages over existing media to warrant the capital investment necessary to make it available. Finally, such analysis can help the designers of new communication systems make them more responsive to communication needs. If history

provides a guide, neither of the new modes discussed above will utterly displace an existing mode, nor are they likely to be fully interchangeable themselves. Instead, they will supplement the existing modes to the extent that they are adequate (or even preferable) substitutes for given communication tasks, and complement them in supporting new types of communication. It seems clear now, for example, that forecasts of the demise of paper in offices were at least premature; computer communication has not reached a stage where it fulfills all of the communicative functions fulfilled by paper.

THE STRUCTURE OF MANAGERIAL AND CLERICAL JOBS

We now move from the structure of communication flows within firms to the structure of managerial and clerical jobs as they relate to communication. As microcomputers have proliferated within firms and, in some cases, been linked into communication networks, a debate has arisen over who should use them. Should executives have PCs on their desks, just as many analysts and lower level managers do? Or should their assistants and secretaries have the PCs? If the executives have the computers, will they (or should they) use them for numerical and graphical analysis? For electronic mail? For composing rough drafts of documents? Or will assistants and secretaries continue to operate the computers at the bidding of executives, as they generally do now? Once again, history provides some interesting insights, though no definitive answers.

Clerical Mediation of Communication: From Telegraph to Filing

As each new communication technology was introduced during the nineteenth century, the issue of who would operate it arose, either explicitly or implicitly. Would the ultimate users themselves (generally owners, entrepreneurs, and speculators in the mid nineteenth century, with managers and professionals joining their ranks by the end of the century) operate the technology, or would the tasks be mediated by lower level employees? In some cases, new job categories were created for operators of the new technologies; in others, job types were eliminated or reduced. In retrospect, the pattern that seems to emerge from these changes lies in the interaction of three variables: ease of operation, cost of an operator, and advantages to the user of operating the technology directly. While the first two are fairly straightforward to assess, the third and perhaps most critical of the variables can be trickier to define. Figure 5 summarizes these variables for most of the communication technologies introduced during this period.

In America, the commercial telegraph was, from its introduction in 1844, mediated by a skilled (and reasonably well paid) operator who received and sent Morse code.¹³ Morse code was difficult to learn and had to be used frequently to be retained. Moreover, since commercial telegraphy operated through central public telegraph offices, businessmen (at this time they were almost exclusively male) had no opportunity to operate it themselves. On the other hand, they gained no inherent advantage

from operating the key directly; a message was no different whether transcribed by the ultimate user or by an operator. As long as the telegraph wires emanated from public telegraph offices, businessmen gained nothing from operating the telegraph directly.

Gradually a few firms began to establish private telegraph lines between the home of an owner and the office, or between an office and a plant to allow rapid local communication without a messenger. The use of an operator at a private home, however, was not reasonable unless volume was high, which was rarely the case at this time; thus, a few owners who really needed the medium for rapid communication with another location learned Morse code. Such private lines operated by the users themselves were relatively rare until 1869, when two printing telegraph companies were formed to erect private lines. The printing telegraph receivers, invented in the 1840s but for some reason not widely adopted at that time, radically improved ease of operation, and might have encouraged more companies to acquire them for communicating rapidly between locations. These printing receivers overcame the major difficulty in operating the telegraph, learning Morse code. Before such printing telegraphs had a chance to get strongly established as an unmediated technology for communicating between two locations, however, the telephone appeared. Since this local communication was better suited to oral communication than written communication, the telephone quickly took over that market.

The issue of mediation arose with the telephone, as well, but very different results. Alexander Graham Bell's first advertising circular for private telephone connections (before exchanges had been invented) described one of its advantages, for business use, over private telegraph lines as follows: "That no skilled operator is required, but direct communication may be had by speech without the intervention of a third person."¹⁴ After point-to-point telephones gave way to telephone exchanges, an operator mediated the exchange as a whole, but, after a brief intervention, the parties to the exchange communicated directly. Thus there was no "operator" in the sense used here. Later, with automatic switching, even that mediation was eliminated. Although certain very busy executives get secretaries to mediate some telephone calls, for the most part telephone has been an unmediated technology ever since.

The telephone differed from the telegraph on all three dimensions, with two of the three pointing toward unmediated use. First, unlike the telegraph, the telephone was easy to use; no special skills were needed. Secondly, and perhaps most importantly, the advantage to users of direct operation were enormous. Used through an operator who took down and transmitted messages, the telephone was the equivalent of a telegraph, through which simple, one-dimensional messages were rapidly conveyed. Used directly, the telephone supported two-way conversation with immediate verbal and vocal feedback. Finally, but probably least importantly, because its use required no special skills and

because a new and inexpensive pool of female labor was just entering the job market at this time, a telephone "operator" (e.g. a secretary) was lower cost than the skilled (and usually male) Morse operator. In spite of these low potential operator costs, the telephone was unmediated from the first. Ease of operation and advantage to the user of direct operation outweighed that factor.

The typewriter, introduced at virtually the same time as the telephone, was introduced as an unmediated technology but almost immediately became used in business with mediation.¹⁵ The typewriter brought a huge influx of female stenographers, typists, and secretaries into the market, creating new job categories and transforming the office. This influx of women created a source of cheap operators, but this cheap labor source would have been available to mediate telephone use as well. The low cost of operators alone, then, was not enough to account for the typewriter's mediation in the business world. Operating a typewriter certainly required more skill than operating a telephone, but less than sending and receiving in Morse code. In the early years of the typewriter, many owners and managers did learn to operate it themselves, so the skill required was not an insuperable deterrent. The key variable in which the typewriter differed from the telephone and resembled the telegraph was that the user (i.e. the originator of the message) gained very little advantage from operating the typewriter directly. Composing at the typewriter produced messy, error-riddled documents that

certainly could not be sent outside the company, and quickly became unacceptable within companies. Documents had to be composed first, then typed. Thus typing was simply a mechanical, time-consuming task that did not benefit the communicator. If speed was at issue, the businessman could always handwrite a message. Otherwise it made no sense to waste his time on a task that could be performed by a cheap operator.

Although filing was a less "technological" innovation in information/communication technology than the others just mentioned, it is a particularly interesting example to analyze.¹⁶ It differed from the first three technologies in that it was mediated in some contexts and not in others. Large central files were always operated by filing clerks. As decentralized files proliferated, however, those in small units were often operated by the managers of the units themselves rather than (or in addition to) being operated by file clerks. The two types of files, central and local, differed on all three dimensions. Operating a large set of central files in a way that made retrieval quick and sure was not a trivial skill. Elaborate indexing and filing systems, some based on the Dewey Decimal library classification system, were created to organize these large files. Local files, however, were frequently small enough to allow for much less exact classification schemes without becoming unusable. Filing clerks were, in general, cheap, but there frequently was not enough work in local files to keep one busy. Thus local filing clerks were in effect more expensive

unless they could perform other tasks as well. Finally, managers stood to gain much more by doing their own local level filing than by filing or retrieving items from a large, company-wide filing system. The central file served as a corporate memory for the entire company, so most of the documents a given manager would see would be irrelevant to that manager. Local files, however, served as a unit's (or even an individual's) memory. Filing and retrieving documents from them reminded the manager of other related documents, and thus served a potentially useful purpose for the manager. Taken together, these three factors frequently tipped the balance in favor of partial or total managerial operation of local files.

Application: Electronic Mail and Personal Computers

One of the questions that arises repeatedly in discussions and research on the "Office of the Future" is the extent to which managers, especially high-level executives, will operate technologies themselves. This analytic framework and the insights gained in applying it to historical cases are useful in thinking about those issues.

Electronic mail, for example, is no more than moderately easy for managers who are inexperienced typists to operate, and, depending on the "user-friendliness" of the system, may be very difficult to operate. As systems become easier to use and as subsequent generations of managers with better typing skills (gained from years of using word processing when they were at

lower levels) work their way up the hierarchy, ease of operation will increase. Cost of an operator for electronic mail is low to moderate. Operators are generally from the same labor pool as typists, though increased skills make them slightly more expensive. The real issue centers around the advantages to the manager of operating the system directly. As we learned in the case of the private telegraph before the telephone was introduced, managers will learn to operate a technology if they really benefit from it. (And a keyboard is easier to operate with a low level of skill than is a Morse key.) The issue of value, then, is the critical one for researchers.

Similar issues arise from managerial and executive use of personal computers for numerical and graphical analysis. Computer operators (i.e. programmers or staff members with computer experience) cost much more than the secretaries who would operate electronic mail. More important than operator cost is the ease of operation. Better software, high level languages, and user-friendly interfaces may make personal computers (either free-standing or connected to a mainframe or minicomputer) easier to operate. Finally, and most critically, we have to examine what advantages the manager or executive gains by direct operation of the personal computer. If working with data directly offers valuable insights and allows managers and executives to try manipulations they would not otherwise consider, then learning to use a system will be worth it to them.

CONCLUSION: THE USES OF HISTORICAL DATA

These examples show how past advances in communication and information technology have affected the structure of the firm, the structure of information flows within the firm, and the structure of managerial and clerical jobs. In each case, the historical case provides us with insights into contemporary cases of technological change. It suggests possible effects -- and side effects -- of introducing new communication technologies. While history is certainly not directly predictive, it gives us another perspective on today's changes, a perspective that may help us analyze and understand those changes.

NOTES

¹Alfred D. Chandler, Jr.'s The Visible Hand: The Managerial Revolution in American Business (Cambridge, MA: The Belknap Press of Harvard University Press, 1977) illuminates the effects of the telegraph, thought that is not his major focus, while Richard B. Du Boff's "Business Demand and the Development of the Telegraph in the United States, 1844-1860" Business History Review 54 (Winter, 1980), pp. 459-479, focuses on the economics of the telegraph, addressing its effects on firms only briefly; Ithiel de Sola Poole's edited collection, The Social Impact of the Telephone (Cambridge, MA: MIT Press, 1977) contains most of the recent scholarly work on the telephone, and its essays are more concerned with the telephone's effects on society as a whole than on its effects on the firm; the effects of the typewriter have received very little scholarly attention except in relation to the introduction of women into the office, as in Elyce Rotella's "The Transformation of the American Office: Changes in Employment and Technology," Journal of Economic History 41 (March, 1981), 51-57; the only work addressing the impact of vertical filing is my own "From Press Book and Pigeonhole to Vertical Filing: Revolution in Storage and Access Systems for Correspondence," Journal of Business Communication, 19 (Summer 1982), 5-26. I address the effects of the firm of most of these technologies, but to varying extents, in my unfinished manuscript book on the development of internal communication systems in American businesses from 1850-1920.

²The pieces of this argument are presented, though in a different context, in The Visible Hand, pp. 6-12.

³Du Boff, p. 478.

⁴A series of letters from E.S. Rice, full-time salaried agent of the E.I. du Pont de Nemours Company, to Francis G. du Pont describe the private code Rice has created for the Du Pont Company, cite its savings in chargeable words, and refer to its improved secrecy in sensitive matters. (Dated July 3, 6, 9, 19, and 23, 1988. The letters are part of the Hagley Museum and Library collection of papers of the Du Pont company, Acc. 504, 16.)

⁵This discussion of the meat packing industry is based on Chandler's The Visible Hand, pp. 299-301, 391-400.}

⁶This discussion of duplicating and filing is drawn from my article, "From Press Book and Pigeonhole to Vertical Filing."

⁷John L. Hanna, "Efficient Methods of Handling Correspondence," Railway Age Gazette 54 (Jan. 10, 1913), p. 61.

⁸J. E. Kingsbury, The Telephone and Telephone Exchanges:

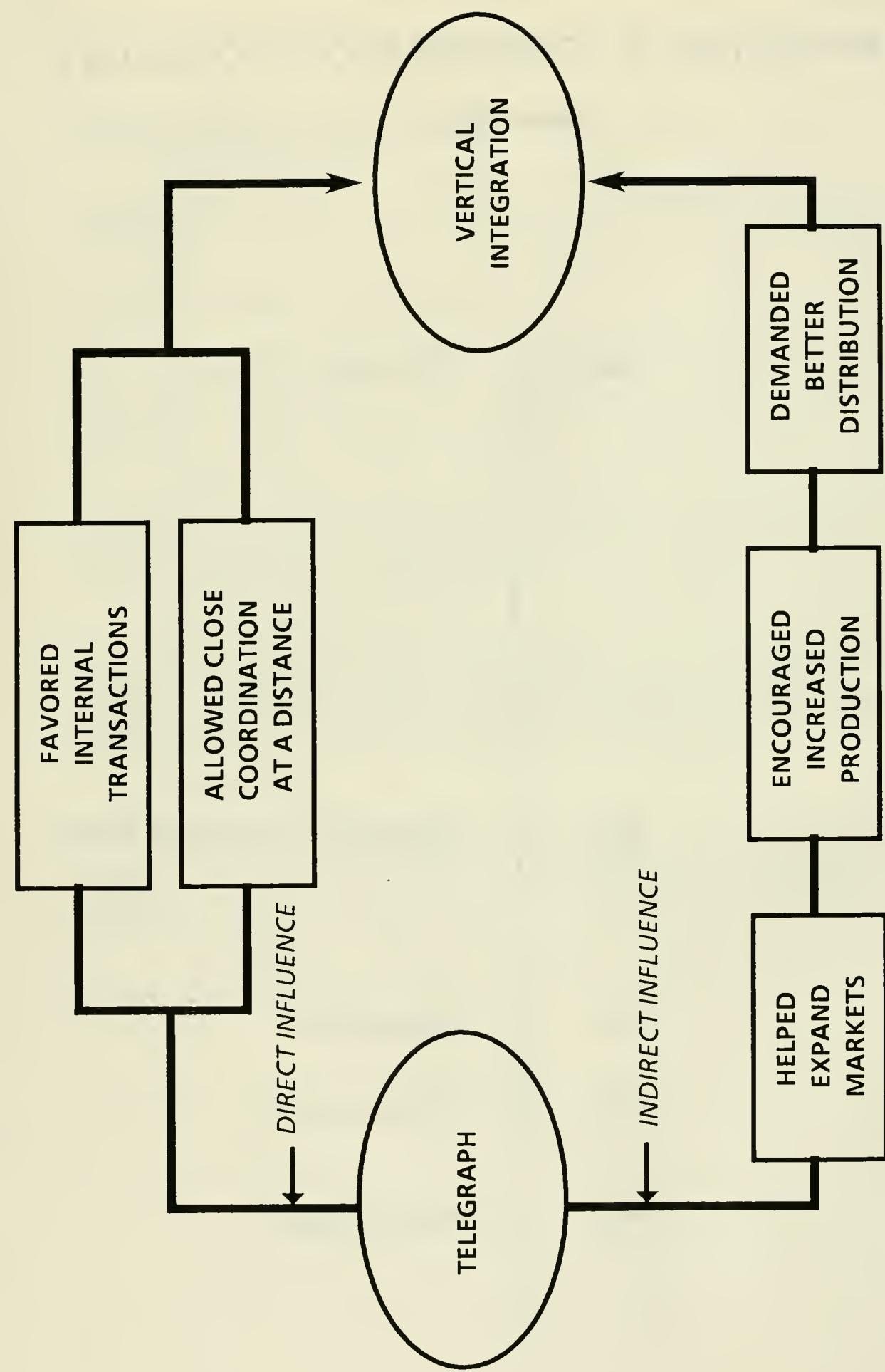


Fig. 2 THE TELEGRAPH ENCOURAGED VERTICAL INTEGRATION

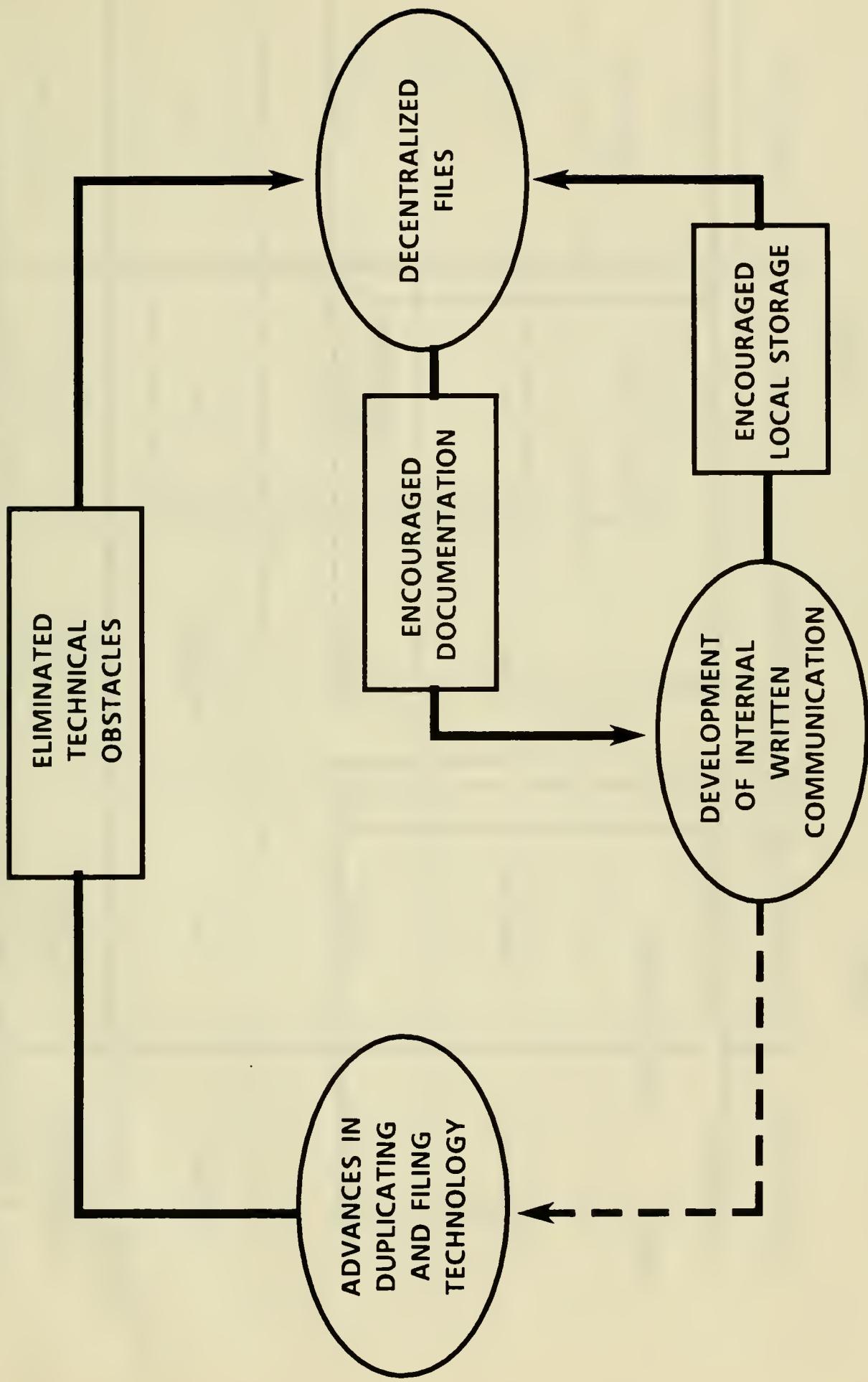


Fig. 3 NEW TECHNOLOGIES PERMITTED DECENTRALIZED FILES, BUT DESIRE FOR LOCAL CONTROL PROMOTED THEM

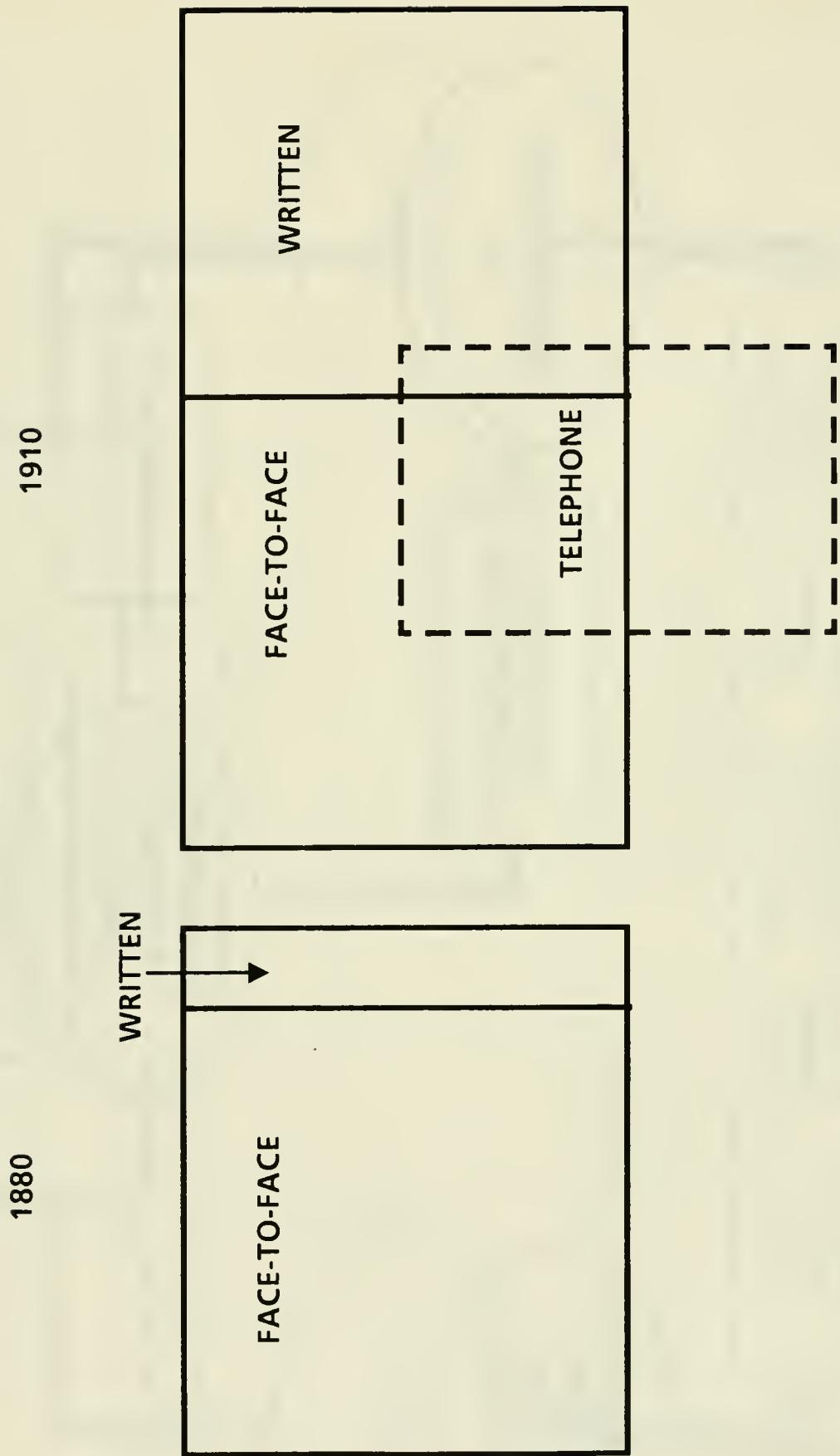


Fig. 4 THE TELEPHONE SUPPLEMENTED FACE-TO-FACE COMMUNICATION
AND COMPLEMENTED WRITTEN COMMUNICATION

Technology	Ease of Operation	Cost of Operator	Advantages to User of Direct Operation		Mediated?
			low	moderate	
Telegraph	low			low	yes
Telephone	high		low	high	no
Typewriter		moderate	low	low	yes
Filing:				low	yes
Centralized		low / moderate		low	
Decentralized		moderate / high	low / moderate	moderate	sometimes

Fig. 5 USE OF COMMUNICATION / INFORMATION TECHNOLOGIES:
MEDIATED OR UNMEDIATED?

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